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1. TITLE OF THE INVENTION

TRANSFORMER

2. CLAIMS

(1) A transformer, characterized in that a conductor is patterned spirally on a non-magnetic insulating substrate, by which a primary coil and a secondary coil are formed.

(2) The transformer according to claim 1, characterized in that a conductor is patterned spirally on one surface of the substrate, by which a primary coil is formed, and another conductor is patterned spirally on the other surface of the substrate, by which a secondary coil is formed.

(3) A transformer, characterized in that a magnetic body is provided to a non-magnetic insulating substrate, and a conductor is patterned spirally around the magnetic body, by which a primary coil and a secondary coil are formed.

(4) The transformer according to claim 3, characterized in that the magnetic body is disposed through the non-magnetic

insulating substrate, and that a conductor is patterned spirally around the magnetic body on one surface of the substrate, by which a primary coil is formed, and another conductor is patterned spirally around the magnetic body on the other surface of the substrate, by which a secondary coil is formed.

(5) A transformer according to claim 4, characterized in that a second magnetic body is disposed around the conductors constituting the primary coil and the secondary coil so that a magnetic circuit is formed with the magnetic body and the second magnetic body.

3. DETAILED DESCRIPTION OF THE INVENTION

The present invention relates to a transformer, in particular, to a transformer suitable to an electronic device manufactured by use of a printed circuit board.

In order to make conventional electronic device compact, elements necessary for a circuit, such as a capacitor, a resistor, a transistor and the like are mounted on a printed circuit board to form an electronic circuit. In this case, a transformer to be connected with the electronic circuit, which is conventionally formed by winding a primary coil and a secondary coil around a core, is mounted on the printed circuit board. As a result, significant space is required above the printed circuit board. When many transformers are mounted on the board, they have to be arranged apart so as not to cause mutual induction due to leakage magnetic flux

and the like, no matter how compact transformers are used. Therefore, significant space is required totally, which inevitably makes the size of the device large as a whole.

Further, the conventional transformer have to be manufactured by winding each coil one by one, which makes the production cost high. Consequently, use of many transformers leads inevitably to increase the cost of the device as a whole, which is also a problem with the prior art.

In particular, when transformers are used for a needle electrode driving circuit in an electrostatography apparatus, a large number of needle electrodes, for example, as many as 1,728 depending on a type of the electrostatography apparatus, are employed, and transformers for driving needle electrode must be provided for every needle electrodes. When such a large number of transformers are used on a printed circuit board, the whole device volume becomes extremely large, and also the cost thereof becomes very high.

Therefore, various improvements have been attempted so as to make the transformer volume compact without reducing boosting ratio, but any satisfactory result has not been attained yet.

The present invention has been made in consideration of the problems with the prior art, and accordingly an object of the present invention is to provide an economical transformer without providing any extra space above a non-magnetic substrate.

To achieve the object, the present invention is characterized in that a conductor is patterned spirally on a non-magnetic insulating substrate, by which a transformer is formed.

The embodiments of the present invention will be described below with reference to the drawings.

FIG. 1(a) and FIG. 1(b) are a plan view and a cross sectional view showing a configuration of a transformer according to an embodiment of the present invention, respectively. On one surface of a non-magnetic insulating substrate 1 made of glass epoxy resin, polyamide, polyester or the like, a conductor 2 and another conductor 3 are formed spirally. These conductors 2 and 3 are patterned by means of photolithography, vacuum evaporation, spattering and the like, with setting the conductor width w_1 and the conductor-to-conductor interval w_2, for example, to 60 μm. Here, a_1, b_1, c_1 and d_1 are terminals of the primary and secondary coils. The conductors 2 and 3 formed on the non-magnetic insulating substrate 1 in this manner constitute the primary coil l_1 and the secondary coil l_2, respectively, shown in the circuit diagram in FIG. 1(c).

When the transformer is formed into the planar configuration on the non-magnetic insulating substrate 1 in this manner, there is no need for mounting a separately fabricated transformer on a substrate like in conventional devices, and therefore there is no need for providing space above the substrate for mounting the transformer. In

addition, conventional transformers require complicated production processes and are expensive because they are manufactured by winding insulated conductors into coils. However, the transformer in the embodiment of the present invention can be manufactured in a simple manner and at a low cost, as mentioned above.

In the case of the first embodiment, two conductors 2 and 3 are employed to form the transformer on the substrate. However, in a second embodiment of the present invention, the transformer may be formed by use of one conductor 4, as shown in a plan view in FIG. 2(a) and a cross sectional view in FIG. 2(b),

In this case, as is the case with the first embodiment, the conductor 4 is formed spirally on the non-magnetic insulating substrate 1 by means of photolithography or the like. The electric circuit diagram in this case is shown in FIG. 2(c), in which the conductor between terminals a_2 and b_2 forms the primary coil l_1, while the conductor between terminals c_2 and b_2 forms the secondary coil l_2.

When the transformer is formed into the planar configuration on the non-magnetic insulating substrate 1 as mentioned above, the number of terminals is small in comparison with the case of FIG. 1, which making it easier to arrange lead wires.

Further, as shown in FIG. 3 as a third embodiment or as shown in FIG. 4 as a fourth embodiment, when a magnetic body 5 is disposed on the substrate 1 by means of adhesion or the

like at the central portion of the conductors 2 and 3 formed spirally as in FIG. 1 or at the central portion of the conductor 4 formed spirally as in FIG. 2, a magnetic flux generated from each portion of conductor passes through the central portion of spiral, as a consequence, the transformer efficiency may be more improved as compared with the first and second embodiments.

In each of the above embodiments, a spiral conductor is patterned to form a transformer with utilizing only one side of the non-magnetic insulating substrate 1. However, as shown in FIG. 5 as a fifth embodiment, a transformer may be formed with utilizing both sides of the substrate 1. Namely, a conductor 6 is patterned spirally on one surface of the non-magnetic insulating substrate 1 by means of photolithography or the like, by which a secondary coil is formed. Likewise, a conductor 7 is patterned spirally on the other surface of the substrate 1, by which a primary coil is formed. When the transformer is manufactured in this manner, the winding number of the conductors increases in comparison with the above embodiments, bringing improved transformer efficiency.

Further, as shown in a plan view in FIG. 6(a) and a cross sectional view in FIG. 6(b) as a sixth embodiment, when a magnetic body 8 is disposed at the central portion of the conductors 6 and 7 formed spirally as in FIG. 5, the transformer efficiency may be far more improved.

In this case, examples of methods for arranging the

magnetic body 8 on the substrate 1 include: a method comprising steps of opening a hole with a diameter smaller than that of the magnetic body 8 in the substrate 1, and pressing the magnetic body 8 into the hole; or a method comprising steps of forming a head portion 9 that is a bit larger than the hole on the magnetic body 8, inserting the magnetic body 8 into the hole, and then adhering the head portion 9 to the substrate 1 as shown in FIG. 6(c).

Still further, a magnetic body 9 may be arranged with covering the secondary and primary coils 6 and 7, which are formed on the substrate 1 by patterning the conductors 6 and 7 spirally, so as to concentrate all the magnetic fluxes generated from each portion of conductors at the magnetic body 8 arranged at the central portion of spiral as shown in FIG. 7(a). When a magnetic circuit is formed with the magnetic bodies 8 and 9 in this manner, the magnetic circuit also functions as a magnetic shield and reduces magnetic flux leakage; as a result, the transformer efficiency is still further improved.

FIG. 7 shows an example of a magnetic circuit covering the primary coil and the secondary coil formed on the substrate 1.

FIG. 7(a) shows a vertical cross sectional view of the transformer, FIG. 7(b) shows a horizontal cross sectional view of the magnetic circuit, and FIG. 7(c) shows a perspective view thereof, a part of which is depicted in a sectional view.

As is seen in the figures, the magnetic circuit is formed with integrating four side leg portions 10 penetrating through the substrate 1 at the external circumference of the coil, the magnetic body 9 comprising the upper yoke portion 11' and the lower yoke portion 11 covering the upper and lower surfaces of the coils, and the main leg portion 8 of a magnetic material arranged at the central portion of spiral.

In practical production, it is convenient to employ a method comprising steps of: forming a magnetic body as shown in FIG. 7(c) having a configuration without the upper yoke portion 11', making notches in the substrate 1 corresponding to portions through which the main leg portion and side leg portions penetrate, engaged the magnetic body with the substrate, and then bonding the upper yoke portion 11' to the magnetic body.

The shape of the magnetic circuit is not always necessary to be circular, and the number and shape of side leg portions, the shape of the main leg portion 8 of magnetic body and the like can be designed arbitrarily.

When the transformer is formed on the substrate 1 in the manner mentioned above, it is possible to reduce magnetic flux leakage, which enhances the function as the transformer and eliminates influence of magnetic flux leakage to other members, making it possible to assemble other electronic circuits near the transformer.

Meanwhile, in the aforementioned embodiments, the shape

of a coil formed by patterning a conductor spirally on the substrate 1 is circular, however, the coil shape is not always to be circular, but it may be optionally designed as a square, an oval and the like.

Further, in the aforementioned embodiments, described are the case where a coil is formed on only one side of a substrate, the case where coils are formed on both sides of a substrate, the case where a magnetic body is arranged, the case where a magnetic body is not arranged, the case where a magnetic circuit is constructed, and the case where a magnetic circuit is not constructed, but it is needless to say that these cases may be combined appropriately to constitute a transformer.

As mentioned heretofore, according to the present invention, since a conductor is patterned spirally on a non-magnetic insulating substrate to form a transformer, it is possible to mount the transformer on a substrate without providing extra space above the substrate, and it is also possible to produce transformers in simpler production process than that for conventional transformers, making it possible to reduce production costs and obtain other advantages.

4. BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 shows schematic diagrams of a transformer where two conductors are patterned spirally on one side of a substrate, wherein FIG. 1(a) is a plan view, FIG. 1(b) is a

cross sectional view, and FIG. 1(c) is an electric circuit diagram thereof;

FIG. 2 shows schematic diagrams of a transformer where one conductor is patterned spirally on one side of a substrate, wherein FIG. 2(a) is a plan view, FIG. 2(b) is a cross sectional view, and FIG. 2(c) is an electric circuit diagram thereof;

FIG. 3 shows schematic diagrams of a transformer where a magnetic body is further arranged at the central portion of the structure shown in FIG. 1, wherein FIG. 3(a) is a plan view, and FIG. 3(b) is a cross sectional view;

FIG. 4 shows schematic diagrams of a transformer where a magnetic body is further arranged at the central portion of the structure shown in FIG. 2, wherein FIG. 4(a) is a plan view, and FIG. 4(b) is a cross sectional view;

FIG. 5 shows schematic diagrams of a transformer where one conductor is patterned spirally on both sides of a substrate, wherein FIG. 5(a) is a plan view, and FIG. 5(b) is a cross sectional view;

FIG. 6 shows schematic diagrams of a transformer where a magnetic body is further arranged at the central portion of the structure shown in FIG. 5, wherein FIG. 6(a) is a plan view, FIG. 6(b) is a cross sectional view, and FIG. 6(c) is a partial cross sectional view; and

FIG. 7 shows schematic diagrams of a transformer where a magnetic circuit, covering a primary coil and a secondary coil formed on a substrate and passing through the central

portion, is formed, wherein FIG. 7(a) is a cross sectional view, FIG. 7(b) is a plan cross sectional of a magnetic circuit, and FIG. 7(c) is a perspective cross sectional view thereof.

1	Non-magnetic insulating substrate
2, 3, 4, 6, 7	Conductor
5, 8, 9	Magnetic body